THE ADDED VALUE OF CMIP6 MODELS FOR SIMULATING WEST AFRICAN RAINFALL AND ITS RELATED EXTREME INDICES

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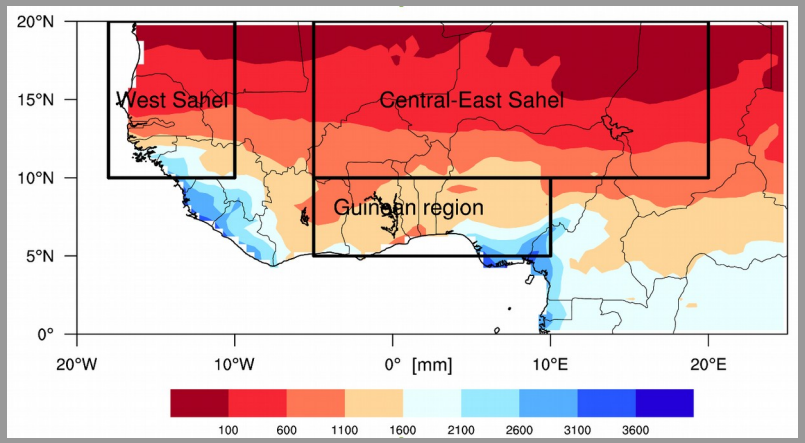
MOTIVATION

West African monsoon precipitation is characterized by a strong variability from intra-seasonal to climatic scales. There, it typically rains from March to October with large differences along latitudes (e.g. Sow et al., Atmosphere 2020). Precipitation is of major importance for the dominantly pluvial agriculture of the region, but intense events can also cause flooding and endanger human lives and property. Studies based on the Coupled Model Inter-comparison Project (CMIP) phase 3 and 5 show that the representation of the West African Monsoon (WAM) mean state and of its response to global warming are both highly model-dependent (Roehrig et al., J. Atmos. Sci. 2013). In this study we analyse the added-value of the new generation models available from the CMIP6 archive in simulating precipitation and its extreme indices over West Africa.

DATA AND METHODS



OBSERVATIONS

Observational Data	Temp. Resolution	Spat. Resolution	Period
ARC2	daily	1°x1°	1983 – 2018
CHIRPS	daily	1°x1°	1981 – 2016
CRU TS4.04	monthly	0.5°x0.5°	1901 – 2019
GPCC FDD v2018	daily	1°x1°	1982 – 2016
REGEN AllStns	daily	1°x1°	1950 – 2016
TAMSAT	daily	1°x1°	1983 – 2017

SIMULATIONS

	CMIP5	CMIP6
HISTORICAL	1850-2005	1850-2014
AMIP-HIST	NONE	1870-2014
SSP585	NONE	2015-2100

CMIP MODELS

Institute	CMIP5	CMIP6
Beijing Climate Center, China Meteorological Administration, China	BCC-CSM1-1m	BCC-CSM2-MR
Canadian Centre for Climate Modelling and Analysis, Canada	CanESM2	CanESM5
National Science Foundation/Department of Energy NCAR, USA	CESM1-BGC	CESM2
Centre National de Recherches Météorologiques, Meteo-France, France	CNRM-CM5	CNRM-CM6.1
Chinese Academy of Sciences, Beijing, China	FGOALS-g2	FGOALS-g3
Geophysical Fluid Dynamics Laboratory, USA	GFDL-ESM2G	GFDL-ESM4
Met Office Hadley Centre, UK	HadGEM2-ES	UKESM1-0-LL
Institut Pierre-Simon Laplace, France	IPSL-CM5A-LR	IPSL-CM6A-LR
AORI (Atmosphere and Ocean Research Institute), NIES (National Institute for Environmental Studies), JAMSTEC (Japan Agency for Marine-Earth Science and Technology), Japan	MIROC5 MIROC-ESM	MIROC6 MIROC-ES2L
Max Planck Institute for Meteorology, Germany	MPI-ESM-MR	MPI-ESM1.2-HR
Meteorological Research Institute, Japan	MRI-CGCM3	MRI-ESM2.0

INDICES

Indices	Definitions
Cumulative Wet Days (CWD)	The number of consecutive wet sequences of more than 5 days (wet spells)
Cumulative Dry Days (CDD)	The number of consecutive dry sequences of more than 5 days (dry spells)
95th percentile	The value above which 5% of the daily precipitation events (days with precipitation higher than 1 mm) are found
Frequency of wet days	The number of days with precipitation higher than 1 mm
Intensity of wet days	The intensity of daily precipitation events

Observations and simulations are all re-gridded on a common 1°x1° grid

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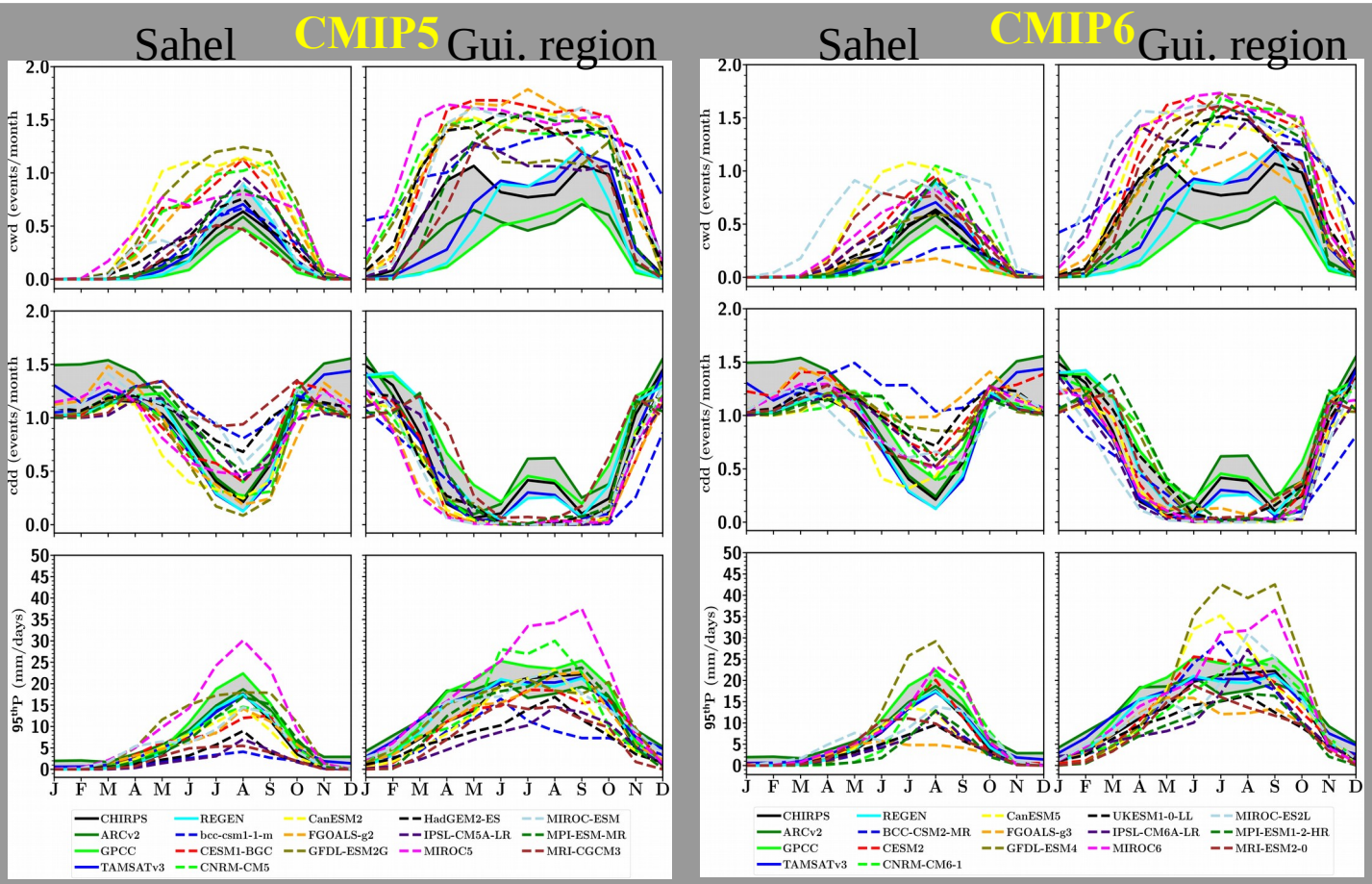
CLIMATOLOGY OF EXTREME PRECIPITATION INDICES



OBSERVATIONAL DATA SETS display a similar structure of the temporal evolution of these precipitation indices over the Sahel. Over the Guinean zone, REGEN and GPCC fail to reproduce the bimodal structure of the wet spell frequency (CWD) and the inter-observation spread is much important on the magnitude of that index.

CMIP5 HISTORICAL SIMULATIONS are generally able to reproduce the annual structure of these indices over the Sahel but with a very large inter-model spread on the magnitude. Likewise, they overestimate the frequency of wet and dry (CDD) spells and underestimate the magnitude of extreme events (95th percentile: 95P). Over the Guinean zone, CMIP5 fails to reproduce the bimodal structure of CWD and CDD and overestimates CWD. Over the Sahel, most CMIP5 underestimate the 95P but are closer to observations than over the Guinean zone.

CMIP6 HISTORICAL SIMULATIONS display a better August-peak of CWD over the Sahel compared to CMIP5 but over the Guinean zone they overestimate its magnitude even more than CMIP5. For CDD and 95P, CMIP5 and CMIP6 are quite similar.

CMIP6 AMIP-HIST SIMULATIONS display more improvement of these indices compared to historical simulations. Some models are able to better reproduce the annual structure and are closer to observation in term of magnitude.

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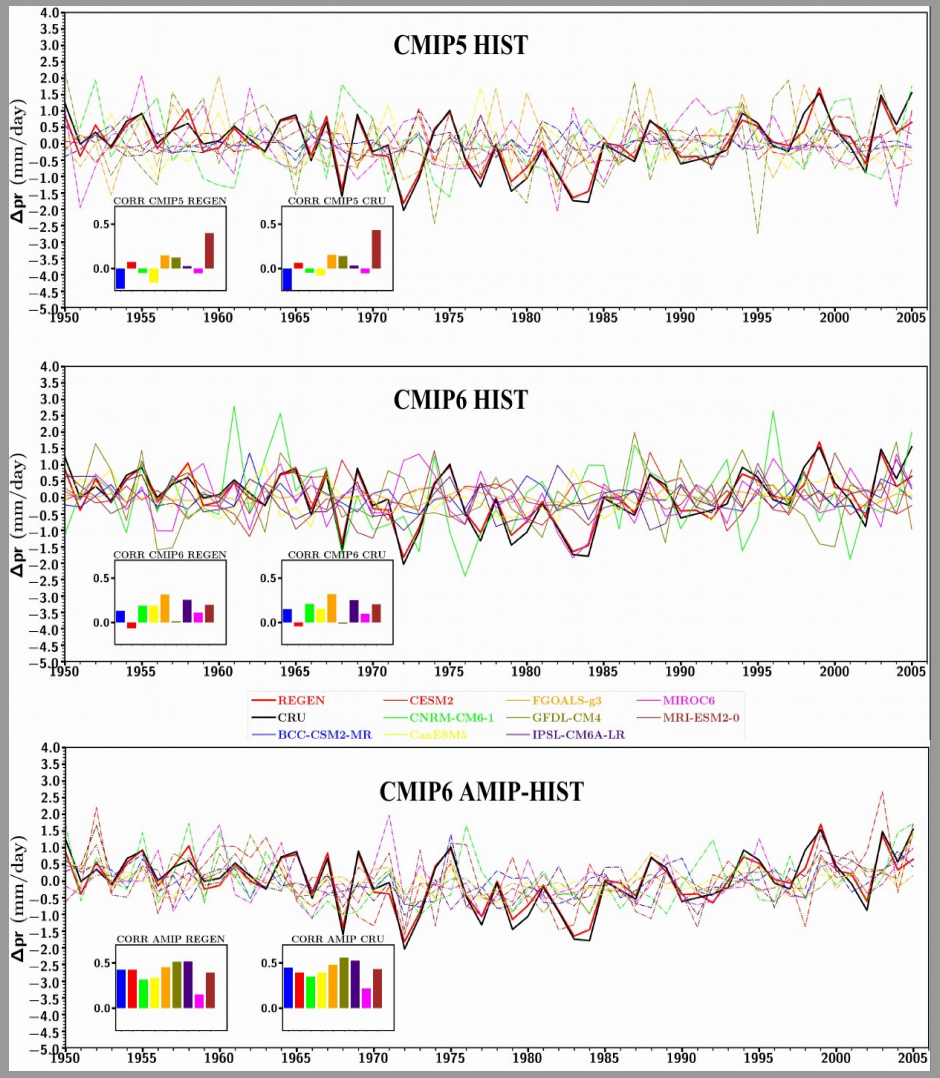
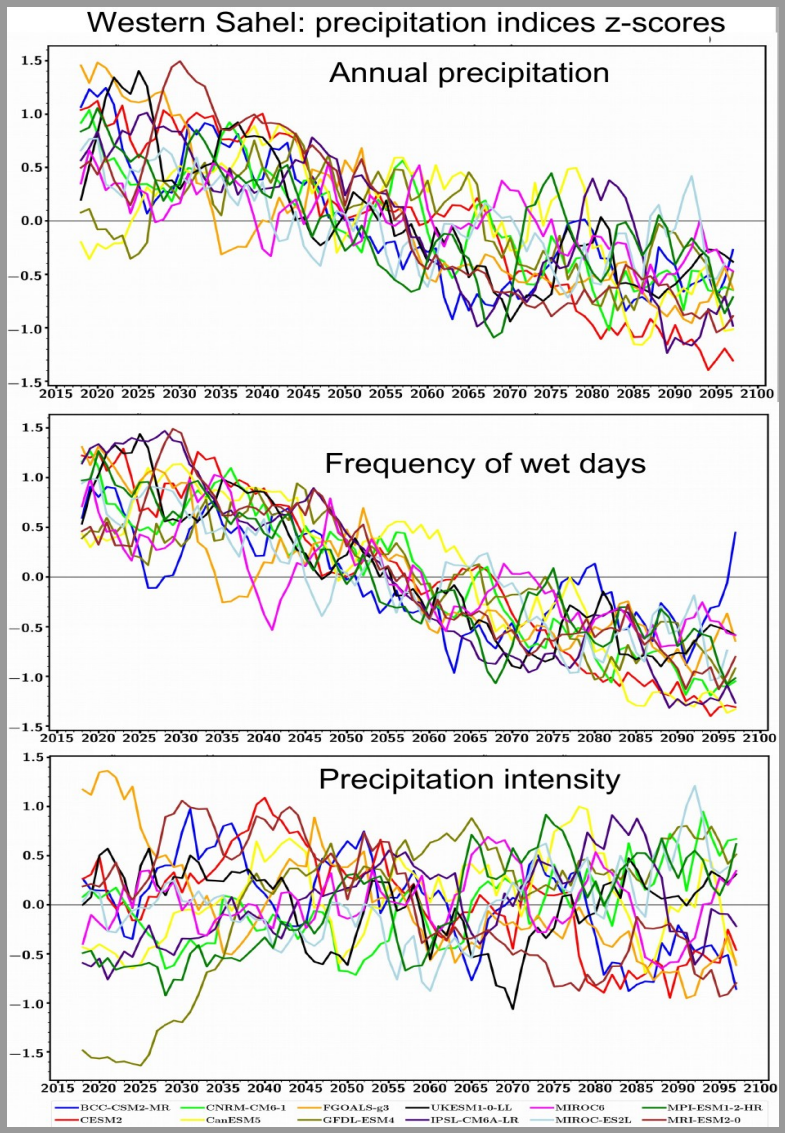
INTER-ANNUAL VARIABILITY OF PRECIPITATION



- Most CMIP5 historical simulations fail to reproduce the inter-annual variability of the JAS mean precipitation over Central Sahel with weak correlation with observations;
- Most CMIP6 historical simulations perform slightly better, with some increase of correlation values;
- Best performances are found in CMIP6 amip-hist simulations with much higher correlation values.

CONTRIBUTION OF INDICES TO FUTURE TRENDS 1/4



➔Can these indexes and their biases help us understand projections of precipitation for different parts of West Africa?

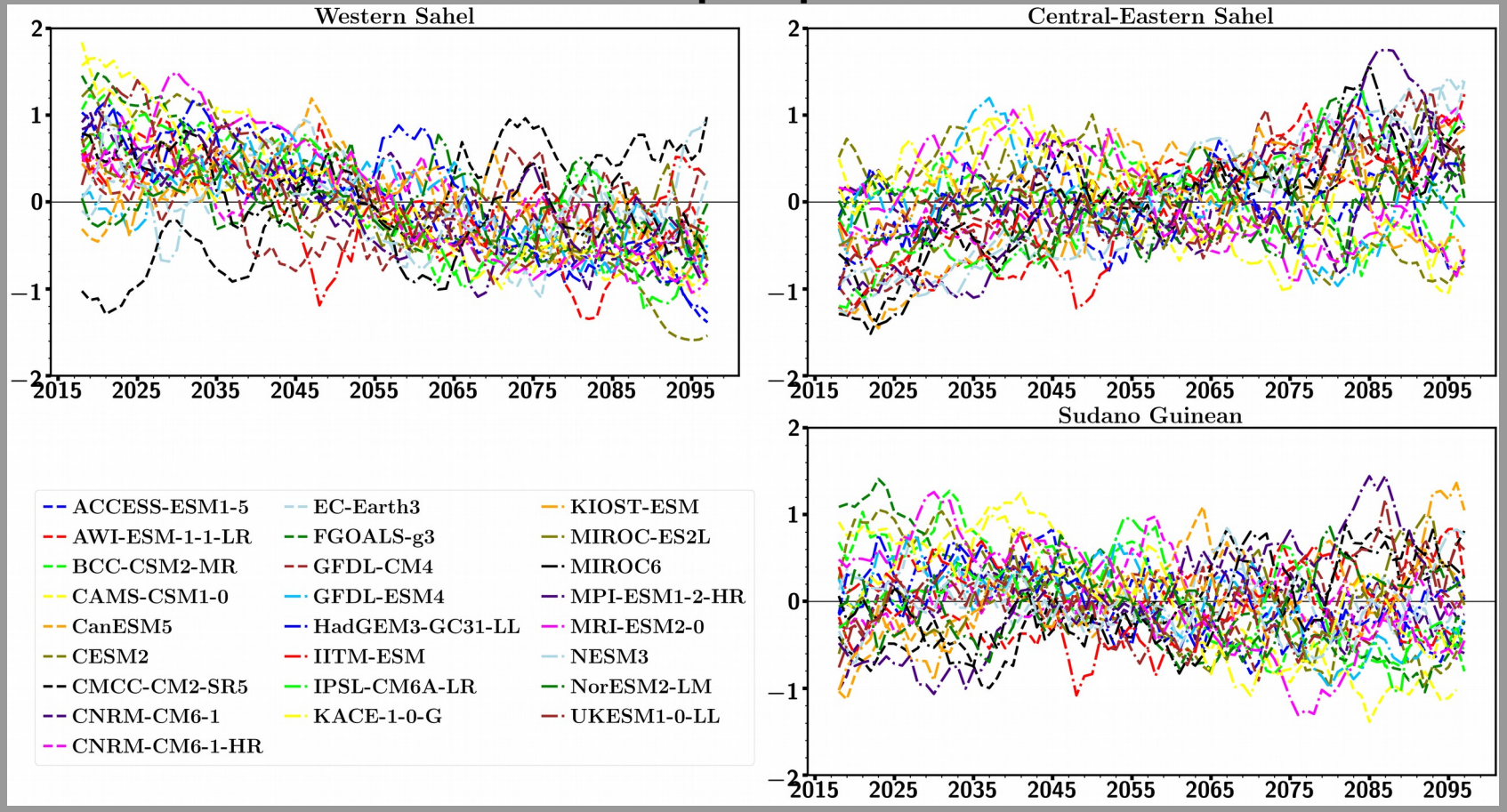
➔For example, over the Western Sahel, models generally agree to a decrease in precipitation over the 21st Century

➔This decrease is strongly associated with a decrease in occurrence of precipitation and not in a change in intensity

➔Similar analysis for different regions (Central Sahel, Guinean Zone) and connecting with observational trends will help understand dynamics of precipitation change

CONTRIBUTION OF INDICES TO FUTURE TRENDS 2/4

Total precipitation



➔ **Decreasing precipitation over the west Sahel, an increase over the Central-Eastern Sahel and no more change over the Guinean zone.**

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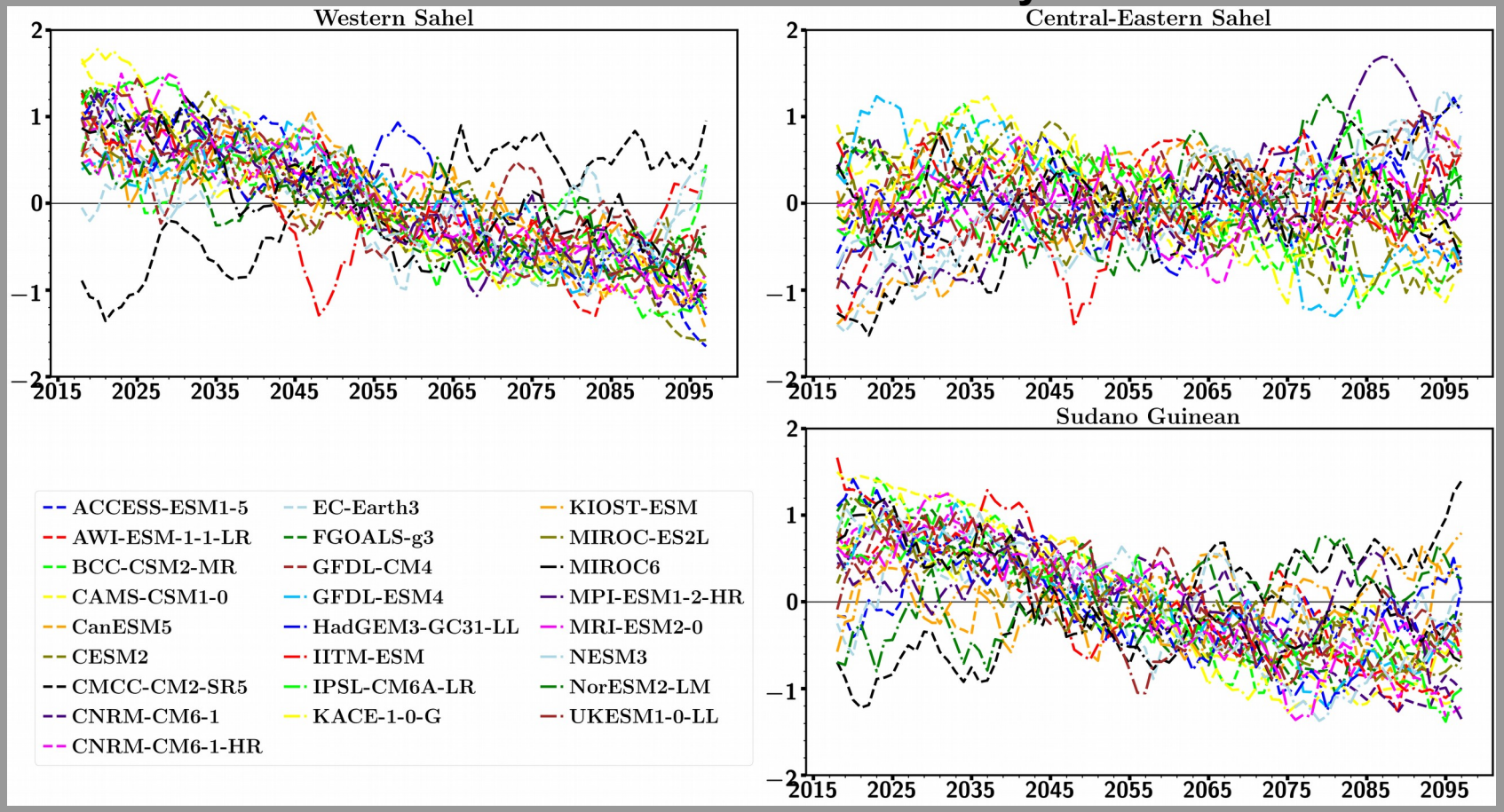
CONTRIBUTION OF INDICES TO FUTURE TRENDS 3/4

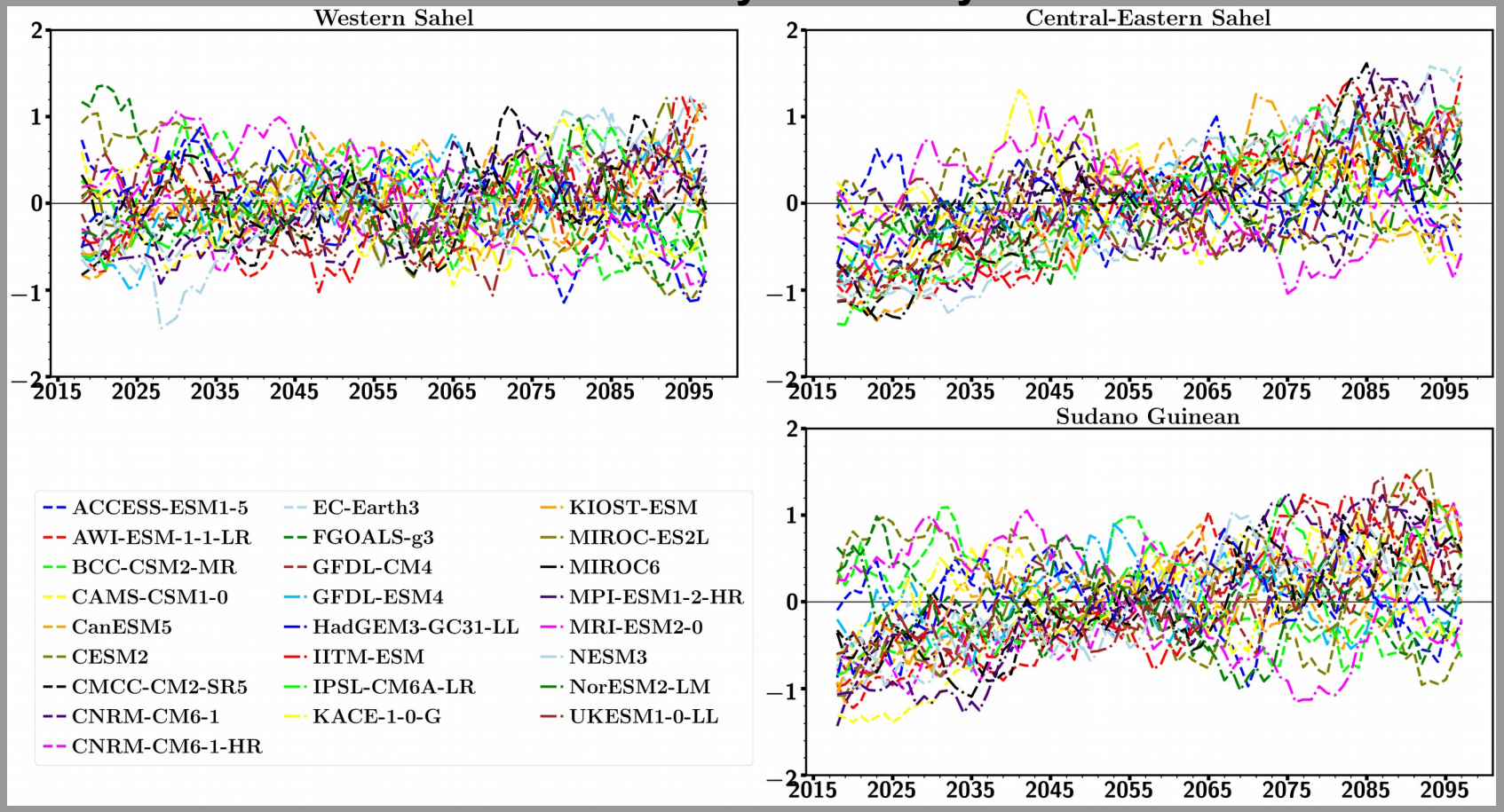
Occurrence of wet days



➔ **Decrease in occurrence of wet days over the west Sahel and the Guinean zone but no change over the Central-Eastern Sahel.**

CONTRIBUTION OF INDICES TO FUTURE TRENDS 4/4

Intensity of wet days



➔ **No change in intensity of wet days over the west Sahel but an increase over the Central-Eastern Sahel and no more change over the Guinean zone.**

CONCLUSION AND PERSPECTIVES

➔Biases in historical CMIP6 are only slightly smaller than in historical CMIP5 over the Sahel and over the Guinean zone, they slightly increase;

➔CMIP6 amip-hist simulations are new, valuable tools for the analyse of multi-decadal variability; in addition, they lead to an improvement of the annual cycle compared to CMIP6 historical;

➔Most of CMIP6 display a decrease of precipitation over Western Sahel in the future, an increase over the Central-Eastern Sahel and no more change over the Guinean region;

➔These changes over the West Sahel are associated with a decrease in number of wet days and no change in intensity, over the Central-Eastern Sahel this is more associated with a increase in intensity and no change in number of wet days ;

➔As a perspective we will look at the contribution of both the occurrence and intensity of wet days to the change in rainfall over these regions.

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